PLEISTOCENE VERTEBRATE REMAINS FROM A CAVE NEAR MONTAGU, N.W. TASMANIA

by

PETER MURRAY
Tasmanian Museum, Hobart, Tasmania

and

ALBERT GOEDE
Department of Geography, University of Tasmania

ABSTRACT

The results are presented of a study of vertebrate remains and associated sediments found in a small, recently discovered dolomite cave (MU-206) in north-western Tasmania. A list of species identified to date is presented and the geochronological and palaeoecological significance of the fossils is indicated.

A description is given of the evolutionary history of the cave and the character of the cave deposits is examined. This is supplemented by an assessment of the condition, completeness and relative position of the fossil material from the site.

PHYSICAL SETTING

Tasmania is a mountainous island with numerous small areas of karst, located predominantly in the high rainfall zone of the western half of the state.

The Montagu karst consists of two small Upper Precambrian dolomite hills rising to a maximum height of six metres above a marshy plain near the Montagu River (figure 1). It is located in the centre of an extensive coastal plain with the land sloping gently northwards towards Bass Strait. Local drainage also trends in this direction.

The area has an extensive veneer of Pleistocene and Holocene sediments ranging from shallow marine and estuarine deposits to aeolian, alluvial and paludal sediments. The Pleistocene cover is interrupted by ridges and isolated outcrops of basement rocks which are predominantly Upper Precambrian and Cambrian in age. A description of the regional geology is given by Gulline (1959). The Precambrian outcrops consist of quartzites, conglomerates and dolomites (Smithton Dolomite) and are widespread. Cambrian rocks include siltstones, tuffs, greywackes, breccias and conglomerates as well as some basic volcanic rocks.

Marine and freshwater Tertiary sediments, including limestones, are of limited extent. They are generally flat-lying in contrast to the strongly folded Precambrian and Cambrian rocks. Outcrops of Tertiary basalts occur locally but are extensive only in the south-east corner of the area shown in figure 1.

Pleistocene high sealevels are indicated by the presence of raised shorelines associated with shallow marine deposits and relict coastal dunes. Further east, three raised shorelines described by Chick (1971) are suggested to be of Last Interglacial age. The highest stands at approximately 20 metres above higher high water mark. Regression of the Pleistocene sea from maximum levels is indicated by extensive series of beach ridges. Some of the older series have been almost completely buried by subsequent peat accumulation.

Artesian springs occur locally in association with deposits of peat and freshwater algal marl. Those near Mella (Mowbray Swamp) are associated with well developed spring mounds. Both the Mowbray and Pulbeena springs are characterized by a very high carbonate content (400 p.p.m. at Mella and 750 p.p.m. at Pulbeena) indicating the presence of dolomite below the Pleistocene sediment cover. Pleistocene vertebrate remains have been recovered from both sites (Gill and Banks, 1956; Hope, 1973; Banks, Colhoun and van de Geer, 1976). Remains have also been recorded from a small dolomite cave (Scotchtown Cave) discovered near Smithton during mining operations in 1942.

The Montagu area is located approximately 41° South and 140° East. It is characterized by a mean annual temperature of approximately 13°C. The mean temperature of the warmest month (February) is close to 17°C while the mean temperature of the coldest month (July) is just above 9°C. The mean annual precipitation is 115 cm with a winter maximum. Not less than 35% of the annual precipitation falls in the three winter months (June-August) but only 15% during the three summer months (January-March).

The Montagu karst is within a wet sclerophyll forest giving way to swamp associations in poorly-drained portions of the surrounding plain. Three caves are known in the area. All contain deposits which include vertebrate remains. Main Cave (MU-201) and Pleisto Scene Cave (MU-206) are located on the western side of the Grunter Road, while the third, an unnamed cave (MU-203) is found in a dolomite outcrop on the opposite side of the road. The direction of dip of the dolomite is SW with the angle of dip varying from 35° to 58°. All the known cave entrances are located on the anti-dip side of the hills where they rise steeply from the surrounding country to form low cliff faces up to 5 metres high. The opposite south-east facing slopes merge gradually into the plain.

CAVE EVOLUTION

The caves have developed under varying groundwater levels which are probably related to past changes in sealevel as the location of the area is marginal to the estuarine plains of the Montagu River. An early stage of shallow phreatic development, related to a high groundwater level, is suggested by arched and flat roofs except where locally modified by rockfall. This appears to have been followed by a period of downcutting under vadose conditions associated with a falling water table. Much of the evidence for this phase is obscured by subsequent intermittent deposition of locally fossiliferous clastic sediments which can be subdivided into three stratigraphic units. This indicates a third phase of cave evolution at a time when groundwater levels were low. The sediments vary from mass-movement deposits containing abundant angular dolomite fragments to clay-rich water laid sediments accumulated under very low energy flow conditions in ponds and underground channels.

A subsequent period of marked but localized flowstone deposition has cemented the surface layers of the underlying clastic sediments in places. This was followed by a period of erosion which dissected some of the cave fill and undermined flowstone-cemented floors to produce "false floors" and protruding ledges. The final episode, which apparently still continues, is another period of localized flowstone deposition.

DESCRIPTION OF CAVE

The entrance is located in a jumble of rocks on a steeply rising north-facing hill slope. It measures approximately 80 cms across and has a roughly triangular shape. A 2.5 metre drop leads to a fissure about one metre wide and four metres long trending in a southerly direction. The floor consists of brown mud with some decaying wood and leaves (figure 2). A small, steeply sloping hole leads downwards about 1.5 metres, from almost directly below the entrance, to a horizontal passage. This passage shows evidence of having been almost filled with strongly-cemented, bone-bearing dolomitic breccia, remnants of which can be seen adhering to the eastern wall.

From the passage a horizontal slit 40 cms high leads to a small chamber (Chamber A) with horizontal dimensions of three by six metres and a maximum height of three metres. The chamber is located immediately below the entrance fissure and separated from it by a "false ceiling" consisting of a double layer of cemented bone-bearing breccia.

On the western side of the chamber, towards the northern end, a 1.5 metre high section of clay-rich alluvial sediments is exposed. The eastern wall appears to be composed mostly of bedrock with some flowstone. From its base extends a six metre long easterly trending passage which contains standing water in winter. It has a clay floor and a bedrock roof containing many actively growing stalactites.

From Chamber A the passage continues to a flowstone bridge. The flowstone sheet was originally formed on the upper surface of the fill sequence as indicated by the adherence underneath of fragments of strongly cemented cave sediment. Dissection of the clastic deposits after deposition of the flowstone has left it suspended above the floor of the present day passage.

At this point a north-south trending passage is entered. It is characterized by smoothly rounded ceilings and has an average height of 1.5 metres. Chamber B is located a short distance along the passage in a southerly direction. Bone-bearing dolomitic breccia is exposed both in the ceiling and the floor. The area of exposure in the ceiling is 0.5 by 2 metres and is contained within a fissure sloping upwards at an angle of approximately 50^{0}. The floor exposures consist of a dissected debris cone extensively covered with flowstone and located on the western side of the passage. At its outer margin it grades at a low angle into the upper surface of the cave fill sequence. This surface has also been dissected and is best preserved as a narrow bench on the eastern side of the passage.

The cave continues for a short distance beyond Chamber B as indicated in figure 2. Bone breccia also occurs near the furthest point reached as shown in section AA' (figure 2) but this site has not yet been excavated or sampled.

NATURE AND STRATIGRAPHY OF CLASTIC SEDIMENTS

A stratigraphic sequence of the deposits is best seen in Chamber A although the base is not exposed (figure 3). Three sedimentary units can be identified. Lowest in the sequence are 1.5 metres of clay rich, fine-grained alluvial sediments (Bed 1) seen in section on the western side of the chamber. At the base the deposits are reddish brown (5YR/4/8) grading upwards into yellowish brown sediments (10YR/5/6) which make up the bulk of the deposit (Japanese Revised Standard Soil Color Charts). The top 40 cms are dark reddish brown (5YR/3/4) and appear to represent a fossil soil (Bed 1 soil). This material is rich in colloidal organic matter but an attempt at pollen extraction was not successful. It also contains sporadic angular dolomite fragments. Small fragments of bone are dispersed throughout but are poorly preserved. The pH varies from 8.5 to 9.0.

The sediments just described are overlain by a dolomite breccia up to 50 cms thick (Bed 2) with a sharp depositional contact. Bed 2 is strongly cemented and forms a projecting shelf making up part of the roof. As well as bones, it contains numerous angular dolomite fragments down to only a few millimetres across. Most of the material has a sparse matrix of fine-grained sediment but locally an open framework occurs. The nature of the material suggests strong physical weathering, probably by frost.

The highest part of the roof exposes the base of the upper unit (Bed 3), which is also a dolomite breccia. Its thickness cannot be measured directly but must be less than one metre. It is also strongly cemented and contains abundant fossil vertebrate remains. The sub-angular dolomite fragments it contains are coarser than in the underlying layer and generally range from 1 to 10 cms in diameter with a few large blocks of up to 40 cms. It also contains a much more abundant matrix of fine-grained sediment. The nature of the dolomite fragments again indicates derivation by physical weathering but under less extreme conditions.

Most of the excavations have taken place in Chamber B where the stratigraphy is less clearly exposed. At an early stage of the excavations material excavated from the roof was kept separate from that excavated from the floor and debris cone. On analysis of the material it became apparent that both contained the same fauna and that the deposits were of the same nature. In subsequent excavations specimens from the two sites were combined.

The sediments excavated from both roof and floor sites in Chamber B are very similar in nature to Bed 3 in Chamber A and occur in the same stratigraphic position. Henceforth they will be referred to as Bed 3B. However, a few scattered, water-rounded quartz pebbles were found as well as one water-rounded quartz crystal and a number of strongly lateritized non-carbonate sedimentary rock fragments. One of the fragments contained a fossil pectinid *Mesopeplum antecedens* (Singleton) - a Tertiary marine fossil reasonably common in the Janjukian and Longfordian (Darragh, T. A., pers. comm.). It has probably been derived from a Tertiary cover rock which has since been eroded. The sediments are mostly bright brown (7.5YR/5/6) and have a pH of 9. Bed 2 does not seem to be represented in Chamber B where Bed 3B rests directly on a lower unit of fine-grained alluvial sediments containing some poorly preserved bone material (Bed 1B).

Beds 2 and 3 represent typical entrance facies deposits which were derived from surface openings under conditions favouring mechanical weathering and mass movement and were transported by solifluction processes to be deposited as sloping sheets and debris fans. The absence of Bed 2 in Chamber B suggests that the surface opening which would have allowed its accumulation was not yet in existence at the time of its accumulation in Chamber A.

DISCUSSION

Bed 1 appears to represent aggradation by a slow-moving vadose stream. It may mark the onset of cold conditions early in the Last Glaciation resulting in soil instability and consequently an increase in sediment load. When accumulation ceased it appears to have been followed by a period of stability perhaps reflecting a return to milder climatic conditions. This is indicated by the fossil soil developed on Bed 1 in Chamber A. Some bones appear to have accumulated on this surface. Two upper incisors probably belonging to *Palorchestes* sp.[1] fall into this category.

Bed 2 is a dolomite breccia representing an entrance facies deposit. The abundance of small angular fragments of dolomite and the occurrence of open frame-work material indicate strong frost weathering. The sediment has all the characteristics of a solifluction deposit and suggests accumulation under surface conditions with an open and discontinuous vegetation cover, at least at the dolomite outcrops.

It has been observed that dolomites of similar age, cropping out further south (42° 57' S) and in a more continental situation near Mount Anne at altitudes of up to 1000 metres, are not at present subject to active frost weathering in winter. Therefore, frost weathering at the Montagu cave site would seem to require a lowering of winter temperatures equivalent to an altitudinal lowering of winter temperature zones of not less than 1200 metres. This corresponds to a reduction in the mean winter temperature of 8°C (Haltiner and Martin, 1957). It suggests that Bed 2 accumulated under conditions approaching maximum cold during the Last Glaciation.

Bed 3 is similar in origin to the middle unit but appears to have accumulated under less extreme cold climate conditions. The dolomite fragments are larger and there is a much greater abundance of fine-grained matrix. In both Chambers A and B this sediment is rich in fossil bone material and the fossil bone material excavated in Chamber B comes from this bed.

EXCAVATION METHODS

Chamber B locality of Pleisto Scene Cave has been extensively sampled. Small samples have been obtained from Chamber A in the same cave, and from one of

[1]

Positive identification of *Palorchestes* from Chamber A is based on a lower incisor.

several deposits in nearby Main Cave (MU-201). Another Montagu locality, (MU-203), yielded a small but interesting collection of fossils. Three types of fossiliferous matrix were encountered in Bed 3B. An extremely durable breccia was broken into pieces so that it could be transported through the narrow passages to the surface. Fossils were freed from thick flowstone rinds and a durable, calcined cave fill with the aid of an air hammer. Other fossils were obtained by exposing them in the softer fill of the floor of the cave.

The high clay content of the fill hampered attempts to employ screening. Bulk samples of fill were thus removed to the laboratory. A slurry of sediment and water was passed through a fine screen in order to sample small mammal remains.

The cave fill was methodically explored for fossil remains. The position and orientation of important individual finds and large concentrations of fossils were recorded in the field. Considerable amounts of fill and matrix remain undisturbed for further reference.

FAUNAL COMPOSITION

The fauna consists primarily of living and extinct species of macropodids. The Macropodinae are represented by *Thylogale* (indistinguishable from *billardieri*), *Macropus* (indistinguishable from *rufogriseus*), *Macropus titan* and the extinct wallaby *Protemnodon anak*. The Sthenurinae are represented by a large sample of *Sthenurus occidentalis* mandibles and maxillae. *Sthenurus* remains were second in frequency to those of *Thylogale billardieri* (figure 4b). *Macropus titan* and *Protemnodon anak* were rare. *Macropus rufogriseus* fossils were more common than *M. titan* and *P. anak* combined. Specimens of *Perameles gunnii* are also relatively common. While few individuals of *Vombatus ursinus* were present, the species provided some of the best preserved cranial remains from the site. The remaining eight species are represented by only one or two individuals each. Two individuals of *Zaglossus* sp. including one nearly complete specimen in partial articulation are among the more interesting fossils from the locality.

Sarcophilus harrisii is represented by a single canine tooth. The tooth is within the range of modern Tasmanian devils. A mandible of *Thylacoleo carnifex* from the "floor" site of Chamber B is the second example of this species recovered in Tasmania. The first specimen was found in Scotchtown Cave (Gill, 1954; Gill and Banks, 1956). A single individual each of *Potorous tridactylus*, *Mastacomys fuscus*, *Hydromys chrysogaster*, diprotodontids ?*Zygomaturus*, *Palorchestes* and an otariid, (*Neophoca* sp.), represented by a lower canine, $P_{\overline{4}}$ and ?$M_{\overline{1}}$ (figure 5c) comprise the remainder of the fauna.

DETERMINATION OF THE EXTINCT SPECIES

This description is intended to give information sufficient to justify the species determinations presented. Detailed descriptions of the fauna are in progress for *Zaglossus* sp. and the Tasmanian Sthenurines.

MACROPODINAE

Macropus (Macropus) Shaw

Macropus (Macropus) sp.

Material: Juvenile left maxilla fragment containing P^2 unerupted P^3, DP^3 and M^1 (figure 6i, j).

Description: Slightly worn P^2, dumbell-shaped in outline, paracone smaller than metacone, separated by a deep lingual and shallow labial constriction, metacone and paracone joined on the labial side by a bifid crest that continues anteriorly into a preparacrista; small posterior cingulum unites with hypocone, crista connects anterior part of hypocone to posterior third of metacone; metastyle present on labial side. Slightly worn DP^3, molariform; high, relatively narrow anterior cingulum sloping lingually; lingual fossette usually present in *M. giganteus* reduced to a crease; midlink strong, expanded lingually and labially in its central portion; lingual valley narrower than in *M. giganteus*. Unerupted P^3, dumbell-shaped in occlusal outline; paracone separated from metacone by a well defined labial and shallow lingual constriction that divides the longitudinal crest extending between the two cusps; paracone comprises anterior third of tooth; prominent low cusp is present on the lingual side of the paracone (absent in

M. giganteus sample employed here); crista connects metacone to hypocone, hypocone relatively larger than forms of *M. giganteus* sample; shallow posterior fovea formed by the posterior cingulum. Slightly worn M^1, morphology as for *M. giganteus* except for narrower anterior cingulum and reduction of the lingual fossette, probably as a result of wear.

The specimen is difficult to assign due to its intermediate size between *M. giganteus* and *M. titan* (Table 1). The apparently relatively larger P^2, P^3

Table 1.   Measurements of maxillary dentitions

	P^2		P^3		DP^3		M^1	
	Length	Max. width	Length	Max. width	Length	Width prot.	Length	Width prot.
Montagu	8.1	5.9	8.9	5.0	9.5	7.5	10.8	8.0
M. giganteus, Tas.	-	-	-	-	9.1	7.2	10.7	8.3
M. giganteus, Tas.	7.5	5.5	8.2	3.9	9.4	7.1	11.3	8.2
M. giganteus	6.3-	4.2-	6.6-	3.1-	7.8-	5.8-	8.7-	6.7-
(Bartholomai, 1975)	7.7	5.4	8.3	4.8	9.5	7.1	11.0	8.6
M. titan, QL.	9.2-	6.6-	8.5-	4.8-	10.1-	7.9-	10.6-	8.2-
(Bartholomai, 1975)	9.8	7.3	11.6	6.3	11.8	9.3	14.7	10.7

and DP^3 to M^1 ratio in the Montagu specimen is not significantly different from either species (Table 2).

Table 2.   Ratios of lengths of maxillary dentitions

	P^2 / M^1	DP^3 / M^1	P^3 / M^1
Montagu	.75	.88	.82
M. giganteus, Tas.	-	.85	-
M. giganteus, Tas.	.66	.83	.79
M. giganteus, QL.	.70-	.86-	.76-
(Bartholomai, 1975)	.72	.90	.96
M. titan	.87-	.80-	.79-
(Bartholomai, 1975)	.92	.95	.80

A possible difference is in the ratios obtained for the maximum width of the same teeth (Table 3).

Table 3.   Ratios of width of protoloph of maxillary dentitions

	P^2 / M^1	DP^3 / M^1	P^3 / M^1
Montagu	.74	.94	.63
M. giganteus, Tas.	-	.87	-
M. giganteus, Tas.	.67	.87	.48
M. giganteus, QL.	.63-	.83-	.46-
(Bartholomai, 1975)	.63	.87	.56
M. titan, QL.	.68-	.87-	.58-
(Bartholomai, 1975)	.80	.96	.59

In this regard the Montagu specimen resembles *Macropus titan* by having slightly higher ratios for all teeth measured than *M. giganteus*. The marginally more robust dentition, the presence of a well developed metastyle on the P^2, the lingual cusp on the paracone of P^3 and the slightly higher anterior cingulum suggest that the individual may be a very small *Macropus titan*. Differentiation

of the two species is problematical because they are morphologically very similar.
Bartholomai (1975: 205) found minor character differences for the lower dentitions
but not the uppers. The major difference is size.

Macropus (Macropus) titan, Owen 1838

Material: Unworn fragment of left I_1, fragment of the anterior portion of a
juvenile mandible containing a partially erupted I_1 and slightly worn P_2
(figure 6c, g, h).

Description: I_1 unworn, morphologically similar to *M. giganteus*, deep and thick;
diastema very short (25.0 mm) due to the young age of the individual; symphysis
deep, rugose; P_2 convex lingually; ridged anterior cuspid gives rise to a short
longitudinal crest; crest terminating in a well-developed posterolabial cuspid;
small cuspule present low on the margin of the crown in the mid lingual area;
large posterolabial cusp formed by cristid extending from the small cuspule.
The specimen is within the size range for *Macropus titan* (Table 4).

Table 4.   Measurements of the mandibular dentition of *M. titan* (mm)

	$I_{\bar{1}}$		$P_{\bar{2}}$	
	Depth	Thickness	Length	Max.width
Montagu	12.2*	6.5*(est)	8.1	4.6
M. giganteus, Tas.	9.5	5.2	6.2	3.0
M. giganteus, Tas.	10.0	5.2	-	-
M. giganteus, QL. (Bartholomai, 1975)	-	-	5.3- 7.0	2.8- 4.0
M. titan, QL. (Bartholomai, 1975)	-	-	7.3- 9.0	3.6- 4.9
M. titan, Tas.	13.5	7.5	-	-

* Less than maximum as incisors are partially erupted

Protemnodon, Owen 1874
Protemnodon anak, Owen 1874

Material: Two right juvenile hemimandibles containing P_2, DP_3, M_1: right and
left juvenile hemimandibles containing DP_3, M_1, M_2; juvenile maxilla with right
and left P^2, DP^3, M^1, M^2; two isolated right second lower premolars and three
incisors (figure 6a, b).

Description: P^2 oval in occlusal outline, paracone less broad than metacone;
labial cingulum ascends apex of paracone producing an oblique, sharply defined
ridge on the anterolabial side of the tooth; mid-labial side of tooth concave;
short, strong sparsely decorated metacrista joins paracone and metacone; small
shallow anterolingual fossette continuous with broader shallow fossette sub-
round in shape; hypocone well developed, connected by an obliquely directed
crista to the metacone; lingual cingulum low, constricted, defining the paracone
and metacone. DP^3 molariform, sub-trapezoidal in occlusal outline; anterior
cingulum low, sloping lingually; forelink absent; labial ridge ascends paracone
as a continuation of the anterior cingulum; anterior fossette shallow, widest
labially; metaloph broader but more compressed mesoidistally than protoloph;
midlink rather low, weak, ascends protocone from mid-inferior portion of
metaloph; paracone and metacone connected by a crest defined by a faint crease
on the inner side of the cusps. M^1 nearly rectangular in outline, metaloph
is slightly broader than protoloph; lophs relatively higher than in DP^3; forelink
absent; anterior cingulum broad, low, somewhat sinuous, forming a shallow fossette.

Metaloph more curved than protoloph; Midlink moderately high; median valley deeper
and narrower on the lingual side; posterior cingulum well developed with a small
fossette near the base of the middle of the metaloph. P_2 suboval in outline,
twice as long as wide, planar or slightly concave lingually; labial side convex;
mesial and distal cuspids joined by a ridge decorated with three small enamel
bulges; bulges separated by corresponding broad, shallow grooves lingually;
cingulum defines a small crease or fossette anterolabially as it ascends the
paraconid. DP_3 molariform, subtriangular in occlusal outline, hypolophid broader
than protolophid; anterior cingulum moderately high; forelink high and prominent,
curving slightly to ascend the protoconid from the labial side of the anterior
cingulum; small labial and large lingual fossettes are present; midlink is low,
weak, ascends hypoconid from a point slightly lateral to the mid point of the base
of the protolophid; weak posterior cingulum. M_1 rectangular in outline; anterior
cingulum broad; strong, short forelink expands distally from near the midline to
ascend the protoconid; large labial fossette and larger lingual fossette are
present on either side; protolophid and hypolophid approximately equal in width;
midlink low; weak posterior cingulum.

Table 5.   Measurements of upper and lower dentitions of *Protemnodon anak*

		P^2		DP^3		M^1	
		Length	Max. Width	Length	Width Prot.	Length	Width Prot.
Montagu	-	11.7	8.0	11.0	9.1	12.5	10.5
P. anak	-	11.6-	6.3-	10.7-	8.0-	10.7-	9.1-
(Bartholomai, 1973)	-	13.5	7.5	11.8	8.8	13.3	11.2
	I_1	P_2		DP_3		M_1	
	Depth	Length	Max. Width	Length	Width Prot'd	Length	Width Prot'd
Montagu	13.1	10.5	5.1	10.1	6.0	12.2	8.1
P. anak	12.8-	10.2-	4.6-	9.0-	5.3-	10.4-	6.9-
(Bartholomai, 1973)	16.3	11.8	5.7	11.8	6.6	13.5	8.6

Prot. = protoloph; Prot'd = protolophid

     The specimens of *Protemnodon* from Montagu conform closely to Bartholomai's
(1973) description of the species. *Protemnodon anak* is also known from Scotchtown
Cave, Smithton and King Island.

                              STHENURINAE

Sthenurus, Owen 1874
Sthenurus (Simosthenurus), Tedford, 1966
Sthenurus (Simosthenurus) occidentalis, Glauert 1910

Material: Right and left juvenile hemimandibles, left and right adult hemimandibles,
nearly complete adult mandible (all with complete dentitions); left maxillary
fragment with P^3, M^{3-4}; right temporal process of zygomatic arch; left M^{3-4},
left P^3, M^{3-4}; ?I^{1-3} (isolated); two lower incisors; isolated left P_3, two isolated
right second premolars; metatarsals IV, one left and two right; probable postcranial
material unassociated; (figure 7a, b, c.).

Description: These sthenurines can be differentiated from *Sthenurus (Simosthenurus)*
orientalis (Tedford, 1966) on the basis of their 1) smaller size; 2) possession of
a short anterior cingulum; 3) symphyseal union not extending posterior to P_3;

4) anterior root of the ascending ramus intersects the protolophid or is anterior to M_4 rather than posterior to it. The largest and most complete mandible is 156.5 mm maximum length. The height of the horizontal ramus posterior to M_4 is 47.3 mm. The dentitions are indistinguishable from *S. occidentalis* except for a slight proportional difference between length and width of the molars and a proportionally smaller P_3. They resemble *Sthenurus orientalis* only in respect to the relative decrease in the size of the P_3 to the molars.

Table 6.   Measurements of the lower dentitions of *Sthenurus*

	P_3				M_1			M_2			M_3			M_4		
	L	AW	PW	HC	L	AW	PW	L	AW	PW	L	AW	PW	L	AW	PW
Montagu	15.1	7.2	10.0	8.5	10.7	9.5	9.9	11.7	10.5	10.6	12.8	11.1	11.0	12.0	11.0	9.9
Sthenurus occidentalis 45093(MC)	16.1	8.1	10.7	10.4	12.3	9.1	9.5	12.6	10.1	10.2	13.1	10.5	10.6	12.3	10.3	9.8
Sthenurus orientalis AMF 10201 (Tedford 1966)	17.0	7.9	10.7	8.4	14.0	10.9	11.2	15.0	12.2	12.7	15.2	13.0	13.2	14.6	12.7	12.1

L = length; AW = anterior width; PW = posterior width

DIPROTODONTIDAE

? *Zygomaturus* and *Palorchestes* sp.

Material: Fragment of left mandible with P_3 (figure 6f); right I_1.

Description: P_3 exhibits light wear on the paraconid; the tooth is subtriangular in occlusal outline; large paraconid comprises the anterior half of the tooth; protoconid extends approximately half as high as the paraconid, metaconid lower than protoconid; faint ridge defines a forelink that descends abruptly into a weak anterior cingulum; prominent bifid crest connects paraconid to protoconid; a low rounded crest descends from lingual side of paraconid to form a broad shelf on the metaconid; posterior cingulum low and broad; ectocingulum descends from protoconid extending to base of paraconid; labial side superior to the ectocingulum is distinctly concave.

Table 7.   Measurements of ? *Zygomaturus* P_3

Length	Maximum Width	Height Crown
16.7	14.1	14.1

The specimen is similar to but smaller than P_3's of *Zygomaturus tasmanicum* (? = *trilobus*) from King Island and Mowbray Swamp (identified as *Nototherium victoriae* and *N. tasmanicum* in the Queen Victoria Museum collection). It is considerably wider than any species of *Palorchestes* but is within the range of *P. azeal* for length. This greater width is due to the triangular outline of the tooth which contrasts with the oval outline of palorchestine lower premolars. The possibility of the tooth being a Dp_3 is ruled out by the absence of a developing P_3 crown and by the long, stout roots which extend down to the incisor
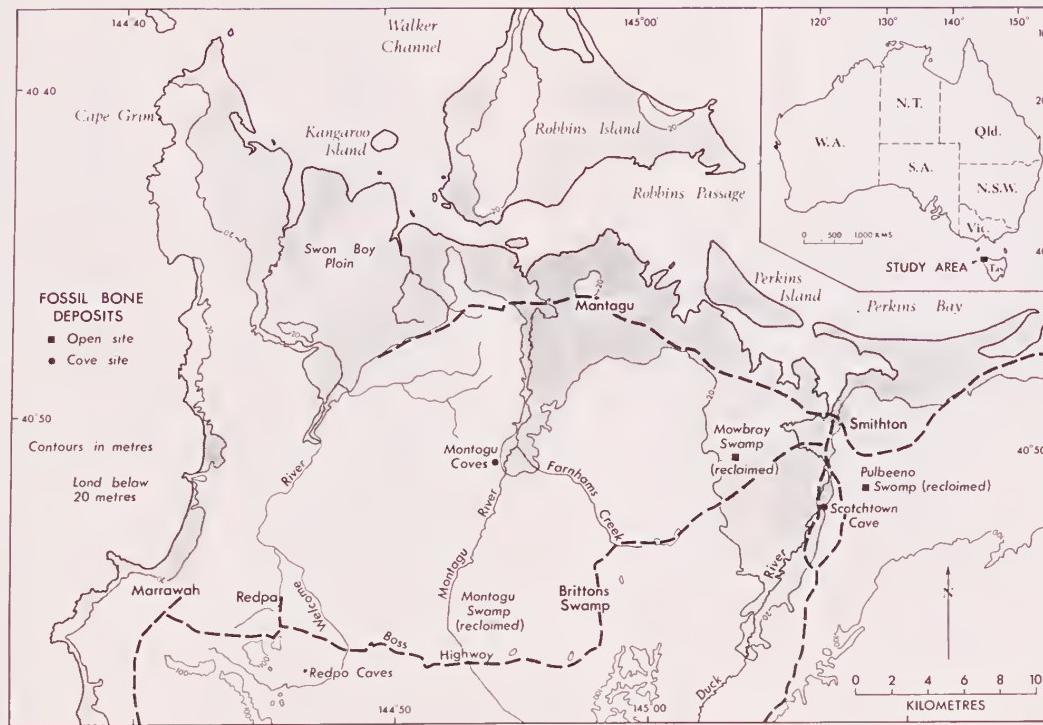
Figure 1   Location map of northwestern Tasmania

PLEISTO SCENE CAVE (MU-206)

Surveyed by: A.Goede, P. Murray
and D. Charlesworth

Chamber A

entrance

Chamber A

bones

bones

too tight

roof site

Chamber B

floor site

grid north

A'

A'

bones

A ——————— A'

too tight

outline

conjectural outline

outline of lower level

vertical change of floor level

direction of downward slope of floor

rocks and boulders

earth

flowstone

flowstone in section

stalactites in section

standing water

0   2   4   6
METRES
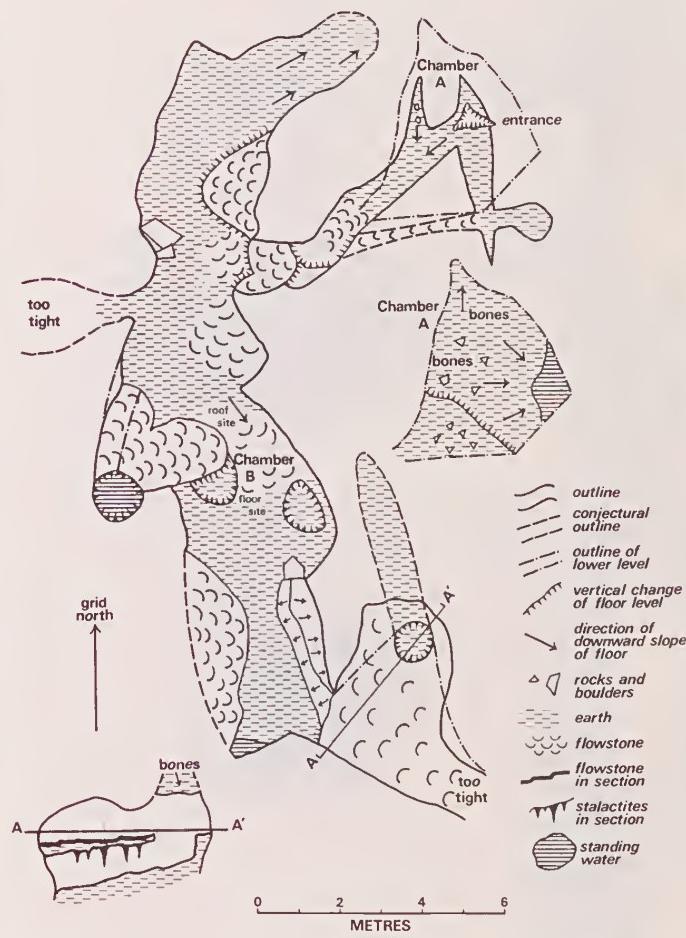
Figure 2   Survey of Pleisto Scene Cave, Montagu
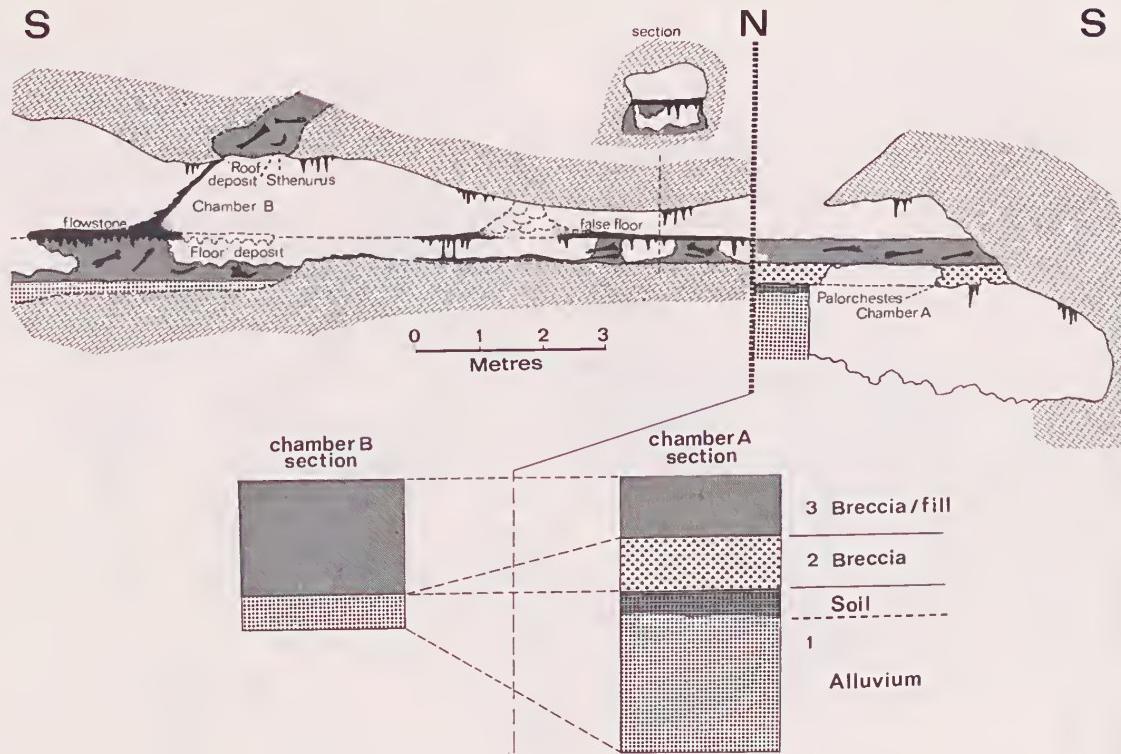
Figure 3   Diagramatic drawing of the stratigraphy of Mu-206.   Chamber A
is reversed in its long axis to aid in showing stratigraphic
continuity with Chamber B.   Diagram below shows inferred
stratigraphic relationships between the two chambers.   Note
the absence of Bed 2 in Chamber B.
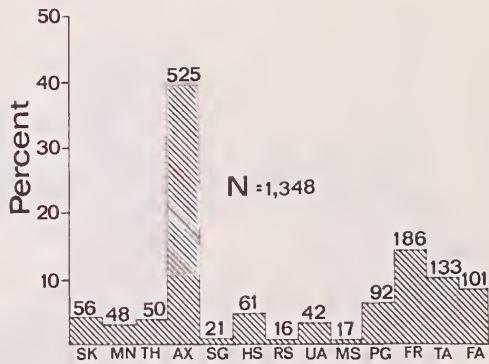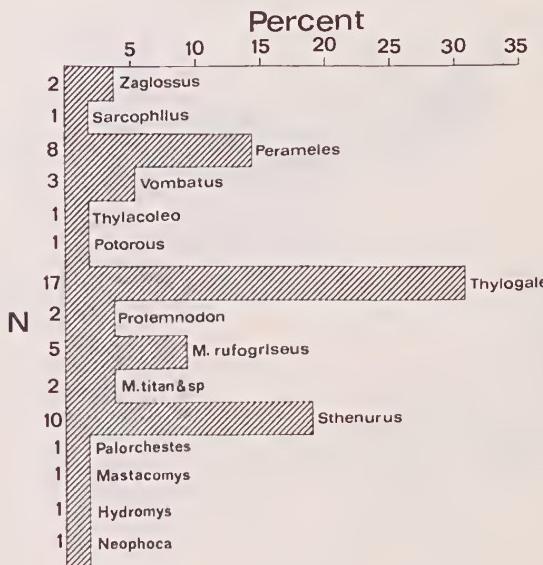
Figure 4   a   Proportion of all identifiable bones expressed as a percentile
histogram. The graph shows all fragments prior to assessment
of a minimum number. Bold numerals indicate the number of each
element recovered. SK, skull; MN, mandible; TH, teeth; AX, axial
(ribs and vertebrae); SG, shoulder girdle; HS, humerus; RS, radius;
UA, ulna; MS, manus; PG, pelvic girdle; FR, femur; TA, tibia;
FA, fibula.

b   Minimum number of individuals of each species from Bed 3B
expressed as a percentile histogram. Bold numerals give the
minimum number.
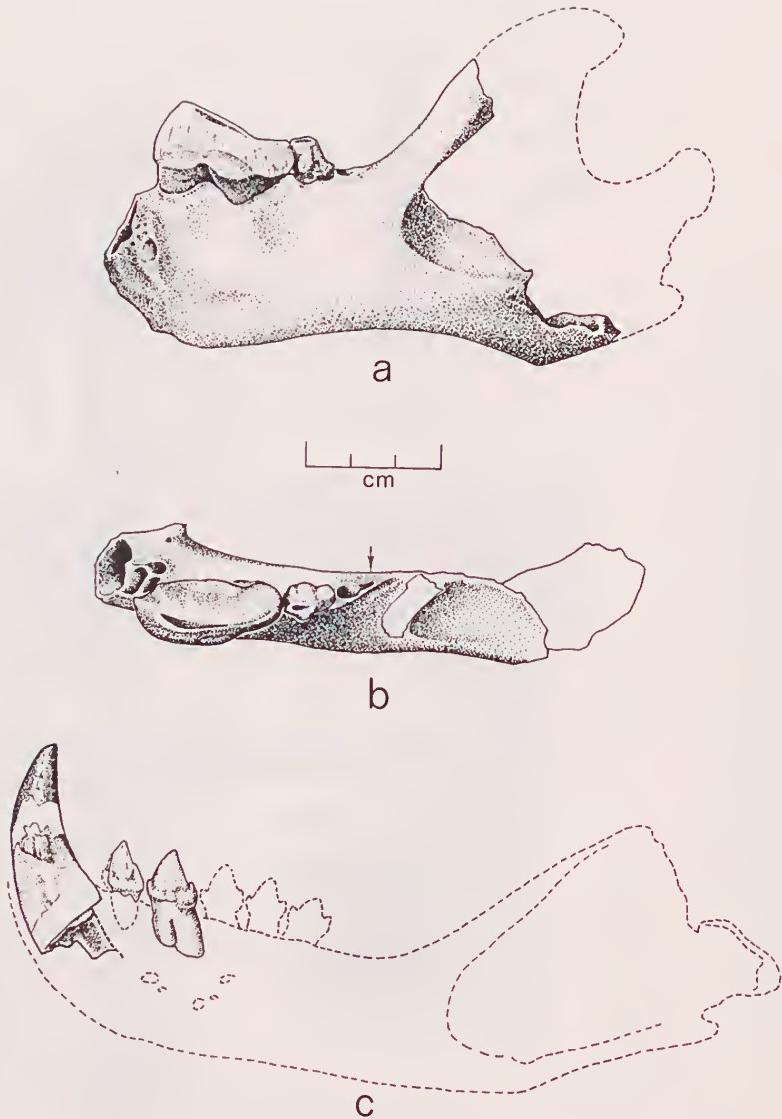
Figure 5   a   Side view of left hemimandible of *Thylacoleo carnifex*, ascending
ramus restored.

b   Occlusal view of mandible.   Arrow indicates possible M_3 alveolus.

c   Left canine, P_4 and M_1 of *Neophoca*.   Scale equals 3 cm.
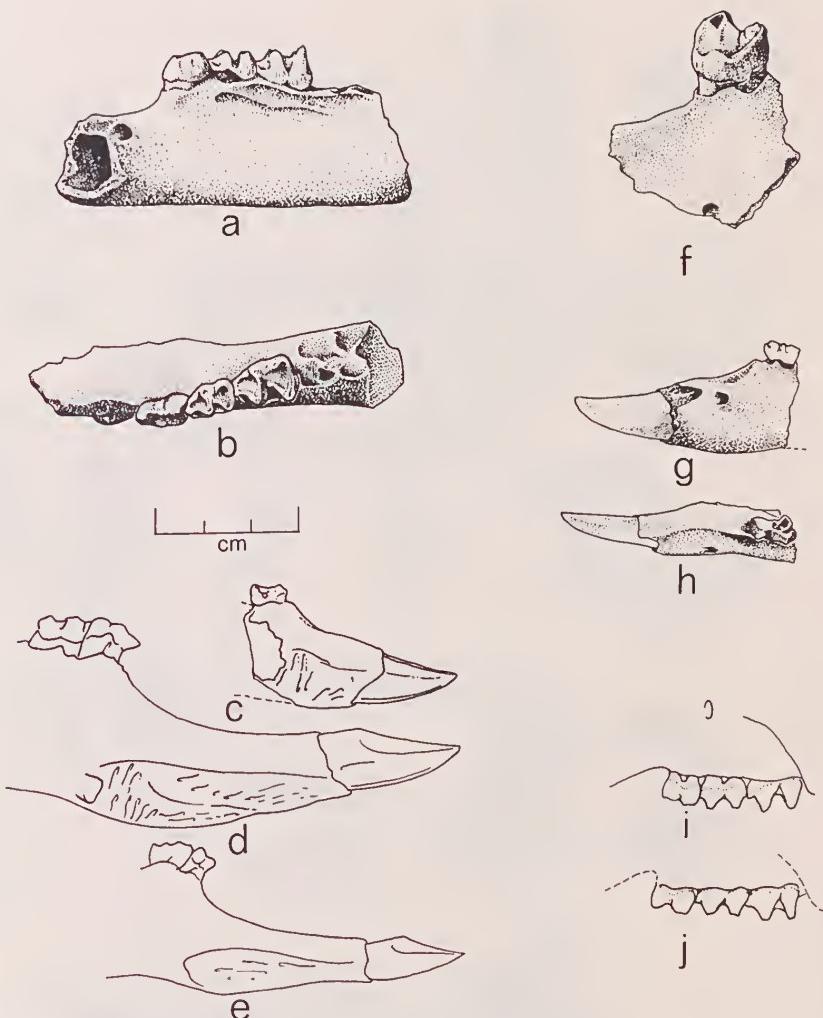
Figure 6 a Left mandibular fragment of *Protemnodon anak*.
    b Occlusal view showing P_2, DP_3 and M_1.
    c Outline of *Macropus titan* mandible fragment from Montagu compared with
    d *M. titan* (Florentine Valley).
    e *Macropus giganteus* (Ross, Tasmania).
    f Left P_3 of unidentified diprotodontid (?*Zygomaturus*).
    g Labial side of mandible of *Macropus titan*.
    h Occlusal view.
    i *Macropus giganteus* P^2, DP^3 and M^1 from Ross, Tasmania compared with
    j *Macropus* sp., Montagu.
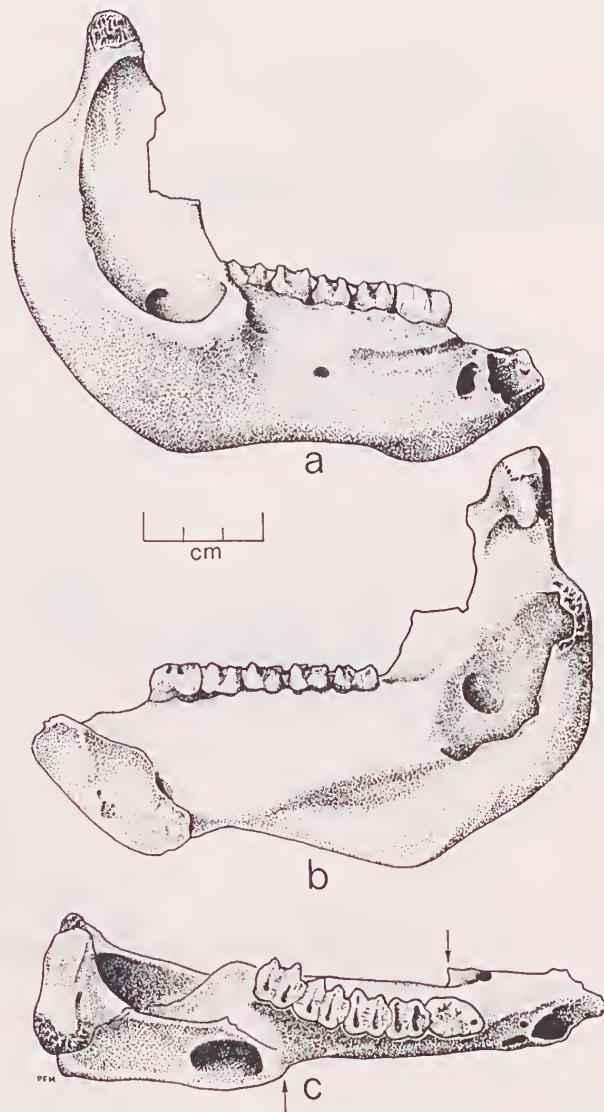
Figure 7   a   Labial view of right hemimandible of *Sthenurus occidentalis*.
           b   Lingual view.
           c   Occlusal view. Arrows indicate posterior margin of mandibular
               symphysis and the anterior root of the ascending ramus.   Dentition
               is P_3, M_1-M_4.
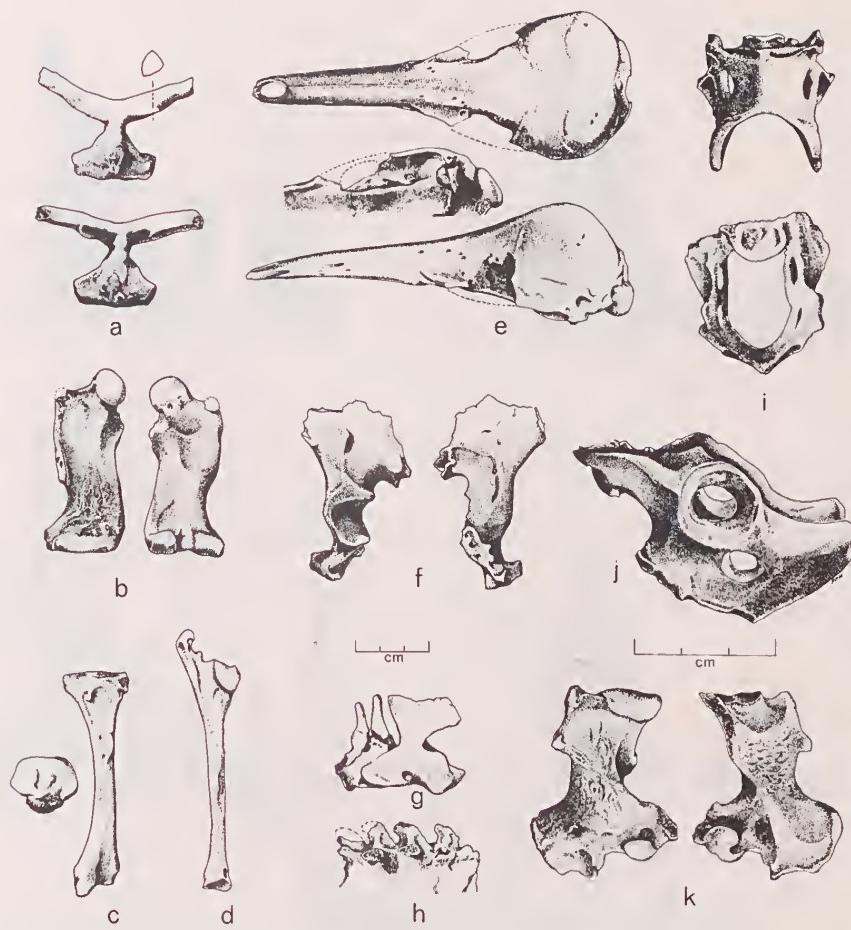
Figure 8   *Zaglossus* sp.

    a   Episternum and clavicles.

    b   Right femur.

    c   Right tibia.

    d   Left fibula.

    e   Cranium.

    f   Right scapula.

    g   Axis, C3-4.

    h   Thoracic vertebrae.

    i   Ventral and frontal view of pelvis.

    j   Side view of pelvis, enlarged to show detail.

    k   Right humerus.
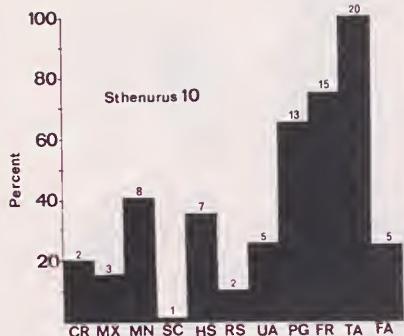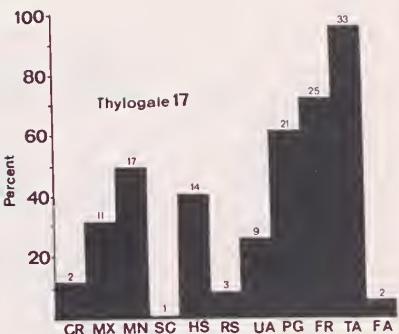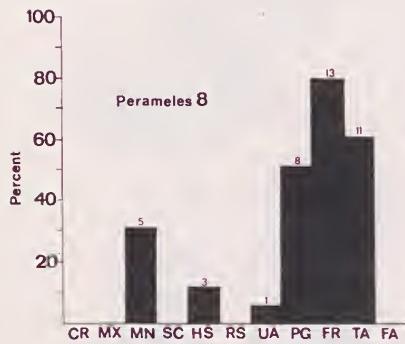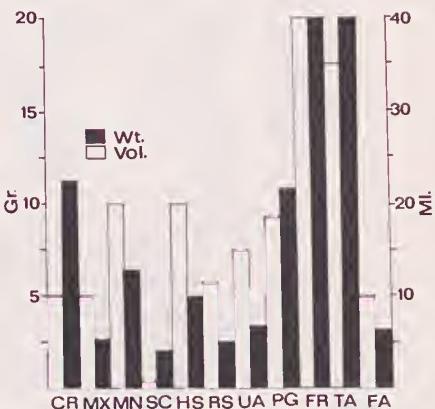
Figure 9   a   Percentile histogram expressing differential preservation of
                 skeletal elements in *Sthenurus occidentalis* (certain post-cranial
                 elements are only tentatively assigned to this species).   Axial
                 elements have been omitted.   One hundred per cent is the expected
                 frequency for each element shown, based on the minimum number of
                 individuals, thus with ten individuals present, there should be a
                 total of 20 specimens of any paired element of that species.   Small
   numerals express the actual number of each element.   CR, neurocranium;
                 MX, maxilla; MN, mandible; SC, scapula; HS, humerus; RS, radius;
                 UA, ulna; PG, pelvic girdle; FR, femur; TA, tibia; FA, fibula.
                 Bold numeral = minimum number of individuals.

            b   Histogram expressing differential preservation of elements of
                 Thylogale.

            c   Histogram expressing differential preservation in *Perameles*.

            d   Histogram showing the weight and amount of displacement volume of
                 each element of *Thylogale*.   Note the similarity in shape of all
                 four histograms.

Figure 10   Semidiagramitic drawing of *in situ* fossils in Bed 3B.   Scale is
approximate, several different planes are depicted as one.
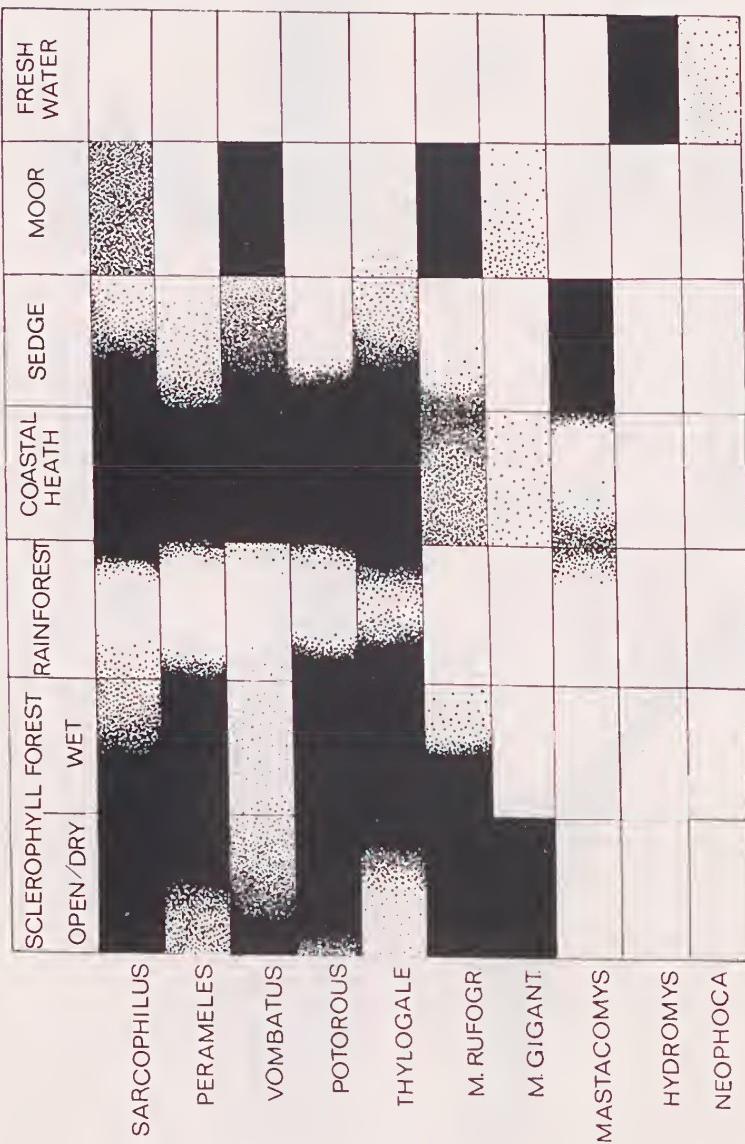
Figure 11   Habitats of living Tasmanian species recovered in Bed 3B. Preference
is expressed by the pure black areas. Suboptimal and rare presence
is shown by varying the density of stipples. Ecotones are expressed
by continuity of shading between borders of listed habitats. All
forms shown in rainforest areas are known to occur only on the verge
or edge of the habitat.
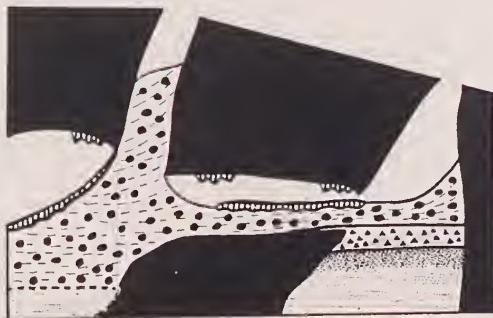
Figure 12   Sequence of events

     a   Initial alluvial sedimentation.
     b   Deposition of Bed 2 with the opening of the Chamber A entrance.
     c   Formation of debris cone, initial flowstone deposition.
     d   Present.

alveolus. The incisor roots were probably of large diameter. The diastema
appears to have been short and the position of the mental foramen relative
to the premolar agrees more with *Zygomaturus* than *Palorchestes*. A lower
incisor from Bed 3B positively identifies *Palorchestes*.

Table 8.   Comparison of measurements of P_3 from
Zygomaturus and *Palorchestes*

|	Length	Maximum Width	Ratio W/L
Montagu ? *Zygomaturus*	16.7	14.1	.84
Tas. Mus. *Zygomaturus*	20.1	16.2	.81
Palorchestes painei (Woodburne, 1967)	12.3	8.3	.67
Palorchestes parvus (Woods, 1958)	14.9	10.6	.71
Palorchestes azeal (Woods, 1958)	17.4	10.4	.60

THYLACOLEONIDAE

Thylacoleo carnifex, Owen 1859

Material: Fragment of horizontal ramus containing P_3 and M_1 (figure 5a, b).

Description: This is a young small adult individual with moderate wear on the
P_3 and M_1. It is distinguished from typical specimens of *Thylacoleo carnifex*
in possessing a narrow, shallow alveolus posterior to the M_2. This may
represent the socket of a tiny third molar.[2]   The length of the P_3 crown of
the Montagu specimen is also relatively short, perhaps in association with the
presence of a third molar. A comparison of Tasmanian and Mainland specimens is
given in Table 9.

Table 9.   Measurements of *Thylacoleo carnifex* mandibular dentitions

	Depth ramus Posterior top P_3	Length Crown P_3	Length Crown M_1	Ratio M_1 / P_3
Montagu	39.5	32.5	11.5	.35
F745 (Woods, 1956)	50.0	40.7	-	-
F2927 (Woods, 1956)	44.0	-	13.7	-
F2929 (Woods, 1956)	44.0	39.3	13.2	.34
F748 (Woods, 1956)	37.0	35.3	11.9	.34
F2928 (Woods, 1956)	44.0	39.2	13.8	.35

Table 10.   Measurements of *Thylacoleo carnifex* from Montagu

Symphysis L x W	Thickness ramus at P_3	Thickness ramus at M_2	Incisor alveolus L x W	M_2 alveolus L x W	? M_3 alveolus L x W
24.0 x 23.0	19.2	15.8	20.3 x 9.4	4.4 x 3.5	3.0 x 1.0

2

Woods (1956: 140) noted a depression immediately posterior to the second
molar of a specimen which he interpreted as the alveolus of a small M_3.

TACHYGLOSSIDAE

Zaglossus, Gill 1876
Zaglossus sp.

Materials: Skull lacking mandible, axis, cervical vertebrae 3-4, thoracic
vertebrae 1-3 or 2-4; sacral vertebra 1, episternum, clavicles, sternal fragments,
ribs, right and left humeri, fragment of additional left humerus, two right
scapulae, and one left scapula, right and left femora, right and left fibulae,
right and left tibiae and innominate bones missing the ilia (figure 8).

Description: Sufficient information for the recognition of the genus is provided
by figure 8. The femur of a similar form was described by Scott and Lord (1922)
as a new species, *Zaglossus harrissoni*. The skull of the Montagu specimen is
within the metric range of living *Zaglossus bruijnii* and it is morphologically
similar to that species. Specimens described by Dun (1895)[3] and Glauert (1914)
as *Zaglossus hacketti* are considerably larger than the Tasmanian form. Material
from Mammoth Cave has certain morphological differences in addition to size
that distinguish it from the Montagu form (Glauert, 1914).

Table 11. Condylobasal lengths of *Zaglossus bruinjii* and *Zaglossus* spp.

Montagu	AMNH (Van Deusen, 1969)							(Dun, 1895) Gulgong
	190859	190862	190863	66194	194702	104020	105072	
165.0	203.0	186.0	193.0	168.0	154.0	180.0	158.0	265.0 (est.)

DISCUSSION

The Montagu Bed 3B fauna is similar to the assemblage from nearby Scotchtown
Cave. The Montagu fauna lacks two additional *Sthenurus* species (*Sthenurus
?orientalis* and *Sthenurus ?andersoni*) recently identified in the Scotchtown Cave
material (P. Murray, in preparation). Both Montagu and Scotchtown Cave contain
a subspecific variant of *S. occidentalis* distinguished from the type by the
characters given in the fauna description section of this paper.

PRESERVATION

A sample of 1,348 identifiable elements were analysed. The overall pattern
of elements recovered indicates a predominance of limb bones and axial elements
(figure 4a). Larger animals are more common than smaller ones.

Significant differential preservation was detected by noting the relative
scarcity of small mammal remains and small skeletal elements of larger species
in the screened bulk samples. The factor of differential preservation was
tested by statistical examination of the remains of the most common species in
the assemblage: *Thylogale*, *Sthenurus* and *Perameles*. A minimum number of
individuals for each of these species was determined. This permitted the
establishment of an expected frequency of all other skeletal elements for the
bones belonging to that particular species. The observed frequency for each
bone was then expressed as a percentage of the expected frequency (figure 9a,
b, c, d). The shape of each histogram is remarkably uniform for each of the
three species. Tibiae, femora and pelvic elements predominate. Mandibles are
relatively common. Rare are scapulae, neurocrania, fibulae and radii.
Differential preservation may have been due to the gradual decomposition of the
less massive bones. Assuming that the robustness of each bone could be expressed
in weight, a sample of *Thylogale billardieri* bones were weighed and plotted. The

3
Dun may have greatly overestimated the length of the skull of his specimen.
An estimate based on the Montagu skull presents a figure closer to 180 mm
total length for the Gulgong *Zaglossus*.

relative compactness or surface area of each bone was estimated by measuring the amount of fluid displaced.

These findings were scaled to the size of the expected frequency histograms for ease of comparison (figure 9d). The close correspondence of the weight/displacement histogram to the shape of the histograms of observed frequencies of elements clearly suggests that the lighter and thinner the bone, the less likely its preservation.

POSSIBLE CAUSES OF FAUNAL ACCUMULATION

Caves are among the best environments for the accumulation and preservation of bones of Recent and Pleistocene animals (Kurten, 1968). The most frequent causes for fossil deposits in caves include use of the cave entrance as a human occupation site, with the bones representing food refuse; the occupation of the cave by hibernating animals (Kurten, 1968), and the use of the cave by carnivores and scavengers, in which case there are remains of its prey, and sometimes remains of the responsible carnivore.

Many caves have treacherous vertical shafts leading to the surface forming natural pitfalls that may trap unwary animals. Animals may be attracted to karst areas because cave openings and overhangs offer shelter. Certain food plants may also grow more prolifically on the carbonate rich soil of the limestone exposures.

THE DEBRIS CONE

Evidence from stratigraphy and geomorphology combined with the statistical analysis of the fauna indicates that the Bed 3B deposit is the remains of a debris cone. The eroded remains of this fan of extraneous sediments originate from the steeply inclined shaft leading to the surface. The entrance of this shaft or fissure has been choked by soil and debris and its exact location is unknown. We have determined however, that the material in the roof is not a clinging remnant of a previously choked horizontal passage. This helps to rule out the possibility that the fossils and sediments were washed in by stream activity.

Configuration of flowstone sheets indicates the original shape of the debris cone (figures 3, 10). In the "floor" site, the greatest concentration of fossils is along the walls in the lowest deposits of cave fill. The debris cone was located in the centre of a rather narrow passage, where erosional activity was concentrated. The deposit gravitated to the sides of the chamber and small recesses in the floor.

CAUSES OF BREAKAGE OF THE BONES

The fossil bone from Bed 3B is permineralized, brittle and often deeply stained with mineral salts. The preservation of bone is extremely poor in the clay-rich sediments (Bed 1B) near the base of the exposed Chamber B "floor" deposit. Excellent preservation of bone is found in the "roof", from the "floor" breccia and from loose stony fill beneath. Nearly all of the specimens are coated with hard calcined matrix. Broken material is common. Ribs are invariably fragmented, as are some of the more robust long bones. Breaks in long bones tend to follow the alignment of osteons. The delicate processes of vertebrae are frequently missing. A *Protemnodon* mandible in the roof deposit appears to have been sheared. Other "sheared" long bones could be seen throughout the deposit where the matrix was undercut by erosion, causing a portion containing part of the specimen to fall under its own weight. Most of the fractures appear to be clean, post-depositional breakage caused by slumping, faulting and creeping of the matrix. Considerable slow, low energy movement of the deposit is indicated.

A few broken bones suggest that damage occurred at the time of deposition. These breaks are characteristic of fresh bones. Spiralled breaks with bevelled and hinged edges may have been caused by the impact of the animal's fall down the shaft.

Evidence of activity of carnivores and scavengers is also present. Three or four specimens have rodent tooth marks and one is extensively damaged by gnawing. A single *Macropus rufugriseus* tibia shows definite evidence of having been chewed on its proximal and distal ends by a larger carnivorous species. Some bird remains (*Rallidae*) show evidence of chewing on the extremities of long bones. These were probably chewed by small scavengers or carnivores. Emu remains are undamaged.

The bulk of the fossil material appears to have been unharmed by scavengers or carnivores. Many of the typical signs of carnivorous activities are absent: the ascending rami are present in many of the mandibles, the epiphyseal regions of long bones tend to be undamaged. The bones of small animals when present, tend to be whole and unmarked. Characteristic tooth marks of carnivores are uncommon (see Douglas, *et al.*, 1966).

The balance of evidence indicates that the fossil remains resulted from animals falling into a steeply inclined shaft. Some scavengers and carnivores may have been attracted by the presence of other trapped or decaying animals. It is probable that animals capable of scrambling could move in and out of the shaft. This would be particularly likely in the case of rodents, small dasyurids and *Sarcophilus harrisii*. All are exceptional climbers. Terrestrial birds such as emus and native hens would be expected victims of the pitfall. The lack of other birds, passerines, ducks and plovers, also tends to favour the secondary role of carnivore activity as a source of the fossils. A wide range of birds would be expected if this were to represent the refuse of active carnivores.

PATTERN OF REPRESENTATION

A final argument that tends to rule out carnivorous activity as a primary cause of the bone accumulation in Bed 3B is found in the pattern of representation of skeletal parts. Bone accumulations resulting from the activity of carnivores appear to have a different pattern of representation to that found in Bed 3B. An interesting faunal analysis of a South African site (Swartklip I) by Klein (1975) provides an excellent example. At Swartklip I and Makapansgat the proportion of femora and tibiae is relatively much lower while mandibles are considerably more frequent. Other elements show a similar, rather great discrepancy in relative abundance between the South African sites and the Tasmanian one. In addition, Klein found a quite different ratio between proximal and distal ends of certain long bones. In Bed 3B these are in approximately equal proportions. Fractures are also less frequent in the Montagu deposit.

ECOLOGICAL IMPLICATIONS

The most common living macropodine species represented as fossils in Bed 3B (*Thylogale, M. rufogriseus*) are presently widely distributed and are associated with many different communities. *Thylogale billardieri* prefers damp areas with dense vegetation. Fern gullies, the verges of rainforest and heathland in the presence of tall dense scrub, are favoured habitats (Green, 1974: 375) (figure 11). *Macropus rufogriseus* is found in habitats ranging from coastal heathland and rainforest verges, to open subalpine areas. It prefers drier areas of sclerophyll forest (Green, 1974: 375). *Macropus giganteus* prefers drier open sclerophyll forests (Green, 1974: 374). It is likely that *M. titan* also preferred open dry habitats. The high abundance of *Thylogale* in the deposit may reflect an optimum habitat for that species. The brush wallaby (*M. rufogriseus*) is somewhat intermediate between the two in its habitat preferences. Evidence from modern cave faunal accumulations shows that in optimum habitats for *Macropus giganteus* there is a greater frequency of that species than of either *Thylogale* or *M. rufogriseus* (P. Murray, unpublished data on caves at the Quoin, near Ross, Tasmania). This suggests that the fossil habitat was suboptimal for *Macropus giganteus* and by inference *M. titan*, and perhaps marginal for *M. rufogriseus*. This implies the presence of scrub, also perhaps wet conditions.

Perameles gunnii prefers open habitats with low ground cover (Heinsohn, 1966), in contrast to *Isoodon* which is more restricted to locally abundant dense wet scrub and coastal heath. *Perameles* is common in the deposit while

Isoodon is absent. This implies that the immediate area was relatively open.

The single specimen of *Potorous* suggests the presence of dense natural vegetation. The species is common in coastal heath communities and in areas with low, dense ground cover (Heinsohn, 1968). The relative scarcity of the species in the deposit suggests that the immediate area was more likely open than covered with dense scrub or forest. Its presence does suggest the existence of a scrub or densely vegetated area nearby, assuming that the cave mouth was within its home range.

The presence of *Mastacomys fuscus* in the assemblage suggests the possible presence of a wet, perhaps treeless sedgeland, its almost exclusive present habitat (Green, 1968, 1974).

The living species of *Zaglossus* is poorly known. It is presently confined to humid montane forests (Van Deusen and George, 1969).

Rails prefer wet areas with dense vegetation. *Tribonyx* occurs in grassy vegetation including the edges of swamps and creeks, and tussocks (Slater, 1970). Emus prefer open grasslands, savanna parklands and scrub.

Hydromys is associated with a wide variety of fresh and brackish water habitats (MacNally, 1960). The presence of both the water rat and *Neophoca* can be explained by the proximity of the site to the Montagu River. The proclivity for sea lions to ascend rocky prominences on which to rest and sun themselves suggests the likely course by which the animal became part of this otherwise non-littoral assemblage. *Neophoca* could also represent the prey of a carnivorous species. This still does not account for its inland occurrence. It is highly unlikely that the remains would be carried more than 10 km unless the teeth represent the durable contents of carnivore dung.

Habitat preferences of extinct species must be inferred on the basis of their morphology, or when possible, a combination of their anatomy and evidence from geomorphology or palaeobotany. *Sthenurus occidentalis* has low molar crowns and trenchant lophs characteristic of a browser. Its high abundance in Bed 3B indicates that a suitable leafy forage was locally available, perhaps in the form of heaths, scrub or a low, open forest community. Raven and Gregory (1946) suggest that *Sthenurus* was a forest-preferring species. The animal's large size and inferred locomotor capability does not favour a dense, closed forest of the type present today at Montagu.

The dentition of *Protemnodon anak* suggests that the animal was a grazer (Raven and Gregory, 1946). It is slightly more common than *M. titan*. The presence of *Protemnodon anak* and *Macropus titan* suggests that suitable grazing habitats were locally present.

The faunal evidence favours an open or partially open habitat with the presence of dense scrub, or digitations of low wet sclerophyll and/or rainforest. A formation consisting of wet hummock sedgeland with bordering scrub and forest associations, similar to those present in the northwest coastal area of Tasmania today would not be inconsistent. Grassland was probably present nearby. The greater compliment of macropod species in the Scotchtown Cave assemblage may be a reflection of the distal grassland community.

The fauna favours the interpretation that the habitat was wet, though perhaps not as wet as analogous modern coastal lowlands on the west coast of Tasmania.

SEQUENCE OF EVENTS

The following is an attempt to synthesize the geomorphological and palaeontological findings. The major stages of cave evolution and deposition of the sediments are summarized in figure 12a-d. The initial phase of sedimentation in the cave (figure 11a) has already been described. The accumulation of Bed 2

probably occurred at some time after a fissure had reached the surface. That fissure is now the entrance to the cave system. The production of the breccia probably took place during a cold dry phase. Some mammals had become trapped in the deposit in a manner probably not unlike their occurrence in Bed 3. Deposition of Bed 3 suggests a period when solution weathering of the dolomite was dominant over frost fracturing. The large amount of sediment, and the extent to which active movement of the material took place suggest a period of active cold climate soil mobilization. The tendency for the dolomite fragments to be larger and more rounded than in Bed 2 is consistent with a cold, wet environment. This agrees with the evidence from the fauna. More sediment and trapped animals continued to accumulate into a debris cone. A flowstone layer formed over the debris cone and its fan extending up and down the surrounding passages. Active creeping of the sediment took place throughout the depositional period which accounts for the extensive scattering and breakage of the fossils. The debris cone may have been partially eroded away at various times during this phase until the shaft became clogged and the sediments within consolidated by calcification. A final stage of erosional activity locally washed the sediment from beneath the flowstone layer leaving false floors.

AGE OF BED 3B

Radiometric dates: Bone collagen dates from Bed 3B suggest a possible terminal Pleistocene age for the deposit. Sample R5001/2 (N.Z.) from the floor of Chamber B yielded a ^{14}C date of 10,100 ± 200 years B.P. An apparently anomalous date of 1,450 ± 210 years B.P. [R5001/1 (N.Z.)] was obtained from the bone of an extinct species in the "roof" deposit. We suggest that the 10,000 year date is a minimum age for the site and that the anomalously young date is due to extensive replacement of the bone.

A terminal Pleistocene date is not incompatible with the stratigraphic evidence. The angular dolomite fragments in Bed 2 could be interpreted as the maximum cold phase of the second hemicycle of the last glaciation. Bed 3 dolomites are more rounded and larger, suggesting increased solution activity during a less cold and probably wetter climatic phase. Bed 3 may therefore represent the terminal Pleistocene or a late stadial. There is no deposit above Bed 3, even though the entrance to the system above Chamber A has apparently remained open since its deposition. This would support the inference that Bed 3 represents the final depositional phase of the last glacial stage.

SUMMARY

The Bed 3B faunal assemblage consists of 1,348 identifiable skeletal elements out of a total of slightly less than 2,000 specimens. An estimated minimum of fifty individuals representing a variety of mammals, a small number of birds and one reptile had become trapped or were killed when they fell into an open fissure leading into a small cave system. There is indication of the activity of carnivores and scavengers having modified some of the remains before they were completely buried by extraneous sediments. Several species of mammals in the deposit are identical with modern Tasmanian species. These include *Thylogale billardieri*, *Macropus rufogriseus*, *Potorous tridactylus*, *Mastacomys fuscus*, *Hydromys chrysogaster*, *Vombatus ursinus*, *Sarcophilus harrisii*, *Perameles gunnii* and an otariid belonging to the genus *Neophoca*. A large tachyglossid has been assigned to the living genus *Zaglossus*. Several species of extinct megafauna are also present. These include *Sthenurus occidentalis*, *Protemnodon anak*, *Macropus titan*, *Palorchestes*, ?*Zygomaturus* and *Thylacoleo carnifex*. *Sthenurus occidentalis* is especially well represented.

In Tasmania, *Sthenurus occidentalis* is far more common than the eastern Australian species *Sthenurus orientalis*. The birds present include emu, and a rallid (?*Tribonyx*). The fauna suggests that at the time the Montagu area was more open than at present, with local dense scrub associations. A seasonally wet substrate is indicated. Grassland was present but not extensive. Evidence from the fauna and the Bed 3B sediments suggests that the environment was cold and wet at the time the animals lived.

Three strata of cave sediments consist of 1) a water born fine sediment having a soil horizon; 2) a frost fractured dolomite containing little matrix; and 3) a cave fill containing fauna and dolomite fragments reflecting some solution activity. These indicate substantial changes over time in the depositional environment at Montagu. The fine sediments in Bed 1 may have been deposited at the beginning of the Last Glacial phase. Deposition of Bed 2 probably reflects a cold, dry phase following an interstadial suggested by the cave soil developed on Bed 1. A subsequent cold wetter phase led to the deposition of Bed 3. Dating of bone collagen by the ^{14}C method suggests that the fauna in Bed 3B lived at the end of the Pleistocene, possibly as late as 10,000 years ago. This implies that Bed 2 deposition reflects the late Last Glacial phase of maximum cold (approx. 20,000 B.P.).

REFERENCES

BANKS, M. R., COLHOUN, E. A. and VAN DE GEER, G. 1976.   Late Quaternary
    Palorchestes azeal (Mammalia: Diprotodontidae) from Northwestern Tasmania.
    Alcheringa 1, 159-166.

BARTHOLOMAI, A. 1973. The genus *Protemnodon* Owen (Marsupialia: Macropodidae) in
    the upper Cainozoic deposits of Queensland. *Mem. Q. Mus.* 16(3), 309-363.

BARTHOLOMAI, A. 1975. The genus *Macropus* Shaw (Marsupialia: Macropodidae) in
    the Upper Cainozoic deposits of Queensland. *Mem. Q. Mus.* 17(2), 195-235.

CHICK, N. K. 1971. Fossil shorelines of the Ulverstone District, Tasmania.
    Pap. Proc. Roy. Soc. Tas. 105, 29-40.

DOUGLAS, A. M., KENDRICK, G. W. and MERRILEES, D. A. 1966. A fossil bone
    deposit near Perth, Western Australia, interpreted as a carnivore's den
    after feeding tests on living *Sarcophilus* (Marsupialia, Dasyuridae).
    Proc. Roy. Soc. W.A. 49, 88-90.

DUN, W. S. 1895. *Rec. Geol. Surv. N.S. Wales*, Vol. 4(3), 121.

GILL, E. D. 1954. Ecology and distribution of the extinct giant marsupial
    "Thylacoleo". *Victorian Naturalist* 71, 18-35.

GILL, E. D. 1968. Aboriginal bone implement from fossil bone bed, Tasmania.
    Rec. Q. Vict. Museum, Launceston, 31, 1-4.

GILL, E. D. and BANKS, M. R. 1956. Cainozoic history of Mowbray Swamp and other
    areas of Northwestern Tasmania. *Rec. Q. Vict. Museum*, Launceston, 6, 1-42.

GLAUERT, F. G. S. 1914. The Mammoth Cave, (*Zaglossus hacketti*, sp. nov.).
    Rec. W. Aust. Mus., v.1, pt. III, 244-248.

GOEDE, A. and MURRAY, P. 1977. Pleistocene Man in South Central Tasmania:
    Evidence from a Cave Site in the Florentine Valley. *Mankind* 11(1), 2-10.

GREEN, R. H. 1968. The murids and small dasyurids in Tasmania, pts. 3 and 4.
    Rec. Q. Vict. Museum, Launceston, 32, 1-19.

GREEN, R. H. 1974. Mammals. *Biogeography and Ecology in Tasmania.* W. D. Williams Ed. W. Junk, The Hague.

GULLINE, A. B. 1959. The underground water resources of the Smithton District. Underground Water Supply Paper No. 5 (Tasmanian Department of Mines), 72p.

HALTINER, G. J. and MARTIN, F. L. 1957. Physical and dynamic meteorology. (McGraw-Hill), 470 p.

HEINSOHN, G. E. 1966. Ecology and reproduction of the Tasmanian bandicoots (*Parameles gunnii* and *Isoodon obesulus*). *Univ. Calif. Publ. Zool.* 80, 1-95.

HEINSOHN, G. E. 1968. Habitat requirements and reproductive potential of the macropod marsupial *Potorous tridactylus* in Tasmania. Mammalia, Tome 32 (1), 30-42.

HOPE, J. H. 1973. Mammals of the Bass Strait. *Proc. Roy. Soc. Vict.* 85, 163-195.

Japanese Revised Standard Soil Color Charts.

KLEIN, R. 1975. Paleoecological implications of the Non-archaeological Bone Assemblage from Swartklip I, Southwestern Cape Province, South Africa. *Quaternary Research* 5, 275-288.

KURTEN, B. 1968. *Pleistocene Mammals of Europe.* Aldine, Chicago.

McNALLEY, J. 1960. The biology of the water rat, *Hydromys chrysogaster* Geoffry (Muridae, Hydromyinae) in Victoria. *Aust. J. Zool.* 8 (2), 170-180.

RAVEN, H. C. and GREGORY, W. K. 1946. Adaptive branching of the kangaroo family in relation to habitat. *Amer. Mus. Novitates*, 1309, 1-33.

SCOTT, H. H. and LORD, C. E. 1922. Studies in Tasmanian Mammals Living and Extinct, *Zaglossus harrisoni.* *Pap. Proc. R. Soc. Tas.* 1921, 13-15.

SLATER, P. 1970. *A Fieldguide to Australian Birds*: Non Passerines. (Rigby Ltd.) 428 p.

TEDFORD, R. H. 1966. A review of the Macropod genus *Sthenurus*, University of California Press, Berkely and Los Angeles.

VAN DEUSEN, H. M. and GEORGE, G. 1969. Results of the Archbold expeditions No. 90, Notes on the Echidnas (*Mammalia, Tachyglossidae*) of New Guinea. *Amer. Mus. Novitates* 2383, 1-23.

WOODBURNE, M. O. 1967. The Alcoota Fauna, Central Australia. *Bull. Bur. Miner. Resour. Geol. Geophys. Aust.* 87, ix + 187 p.

WOODS, J. 1956. The Skull of *Thylacoleo carnifex*. *Mem. Q. Mus.* 13 (2), 125-140.

WOODS, J. 1958. The extinct Marsupial genus *Palorchestes* Owen. *Mem. Q. Mus.* 13(4), 177-194.

APPENDIX

SPECIES

FOSSIL LOCALITIES — groups: **MONTAGU** = Chamber B (MU-206), Chamber A (MU-206), Main Cave (MU-201), MU-203; **NW TAS** = Flowery Gully, Scotchtown, Mowbray Swamp, Pulbeena Swamp; **S TAS** = Beginners Luck**; **BASS STRAIT ISLANDS** = King I, Flinders I, Cape Barren I, Passage I, Preservation I, E. Kangaroo I, Deal I, Erith I, Three Hummock I.

Species	CHAMBER B (MU-206)	CHAMBER A (MU-206)	MAIN CAVE (MU-201)	MU-203	FLOWERY GULLY	SCOTCHTOWN	MOWBRAY SWAMP	PULBEENA SWAMP	BEGINNERS LUCK**	KING I	FLINDERS I	CAPE BARREN I	PASSAGE I	PRESERVATION I	E. KANGAROO I	DEAL I	ERITH I	THREE HUMMOCK I
AVES	X	X			X	X	X	X	X	X	X	X	X	X	X	X		
REPTILIA		X			X				X	X	X		X	X	X	X		
Tachyglossus			X	X	X				X	X								
*Zaglossus**	X	X			X				X									
*Macropus titan**	X				X													
Macropus giganteus	?		X	X	X										?			
Macropus rufogriseus	X	X	X	X	X	1	4		X	X	X	X		X	X	X		
Thylogale billardieri	X	X	X	X	X			X	X	X	X	X		X	X	X		X
Potorous tridactylus	X	X	X	X							X	X				X		X
Bettongia cuniculus				X														
*Protemnodon anak**	X				X				X									
*Sthenurus occidentalis**	X	X			X		3		X	X								
*Palorchestes azeal**	X	X			X	X	X											
*?Nototherium**					X	X	X		X									
*Zygomaturus**	?				X				X									
*Diprotodon**									X									
Trichosurus vulpecula					X								X		X	X		
Pseudocheirus convolutor		X			X				X	X	X							
Cercartetus nanus					X													
*Thylacoleo carnifex**	X				X													
Vombatus ursinus	X	X	X	X	X	X	5		X	X	X	X			X			
*Phascolonus**					X													
Isoodon obesulus					X						X	X	X					X
Perameles gunnii	X	X			X	X			X									
Antechinus spp.					X				X		?		?		?			
Sminthopsis					X													
Dasyurus viverrinus					X				X					?				
Dasyurus maculatus			X	X	X				X	X	X							
Thylacinus cynocephalus	X				X	X												
Sarcophilus harrisii	X				X	X				X								
Mastacomys fuscus	X				X				X									
Pseudomys higginsi					X		2		X	X								
Rattus lutreolus					X				X	X	X	X	X		X	X		
Hydromys chrysogaster	X																	
CHIROPTERA					X													
PINNEPEDIA (*Neophoca* sp.)	X																	

MONTAGU   NW TAS   S TAS   BASS STRAIT ISLANDS

FOSSIL LOCALITIES

1.   Listed as "wallaby" in Gill and Banks (1956)
2.   Listed as "rodent" in Gill and Banks (1956)
3.   Listed as "kangaroo" in Gill and Banks (1956) identified as either *Procoptodon* or *Sthenurus*, see p. 23 (ibid.)
4.   Confusion arises here as to what is meant by "wallaby". Gill and Banks (1956: 23) suggest that this is *Macropus rufogriseus*
5.   *Vombatus* was actually not recovered from the swamp deposit, but from a nearby cave (ibid. p. 23)
*   Extinct, or as in the case of *Zaglossus*, extinct in Tasmania and Australian mainland
**   Recently discovered fossil cave in the Florentine Valley, Southern Tasmania